Vol. 15(1), pp. 1-9, January-June 2024
DOI: 10.5897/JPAP2023.0148
Article Number: 4BC0BD171802
ISSN 2141-260X

http://www.academicjournals.org/JPAP

ACADEMIC JOURNALS
expand your knowledge

Journal of Physiology and Pathophysiology

Full Length Research Paper

Evaluation of the ventilatory function of Senegalese dental laboratory technicians

Papa Abdou Lecor[1,2]*, Malick Gueye[1,2], Abdou Khadir Sow[2], Moctar Gueye[3] and Abdoulaye Ba[2]

[1]Department of Physiology, Institute of Odontology-Stomatology (IOS), Cheikh Anta Diop University, Dakar (UCAD), Senegal.
[2]Laboratory of Physiology and Functional Explorations, FMPO/UCAD, Dakar, Senegal.
[3]Department of Prosthodontics, IOS, UCAD, Senegal.

Received 19 September, 2023; Accepted 15 January, 2024

The objective of this study was to assess the ventilatory function of Senegalese dental technicians by comparing them to a control group of healthy individuals not exposed to dental laboratory products. A cross-sectional descriptive and comparative study was conducted, and spirometric examinations were performed in the Respiratory Functional Investigation room of the Laboratory of Physiology and Functional Explorations, FMPO/UCAD, Dakar, Senegal. The collected spirometric parameters included forced vital capacity (FVC), maximum expiratory volume in 1 second (FEV1), Tiffeneau ratio (FEV1/FVC), maximum expiratory flow at 25% of the FVC (FEF25%), maximum expiratory flow at 50% of the FVC (FEF50%), maximum expiratory flow at 75% of the FVC (FEF75%), and maximum expiratory flow between 25 to 75% of the FVC (FEF25-75%). A total of 77 subjects were included in the study, divided into two groups: a group of prosthetists (32 prosthetists) and a control group (45 individuals). All measured spirometric parameters (FVC, FEV1, Tiffeneau ratio FEV1/FVC, FEF 25%, FEF 50%, FEF 75%, FEF 25-75%) were significantly higher in the control group compared to the prosthetist group. No proximal obstructions were identified, but distal (12 prosthetists) and central (5 prosthetists) obstructions, as well as restriction (5 prosthetists), were more prevalent in the prosthetist group, showing statistically significant differences between the two groups ($p \leq 0.05$). These findings indicate a compromised ventilatory function in dental technicians compared to the control group. Consequently, a comprehensive risk analysis of Senegalese dental laboratories is recommended to formulate a Single Safety Document, evaluating both the material and technical environment and the efficacy of existing protective measures, considering individual workstations.

Key words: Dental technicians, metal-resins, spirometry, ventilatory function, obstructive ventilatory disorder, restrictive ventilatory disorder.

INTRODUCTION

The manufacture of dental prostheses, including dentures, orthodontic appliances, crowns, and bridges,

*Corresponding author. E-mail: papalecorchdent@yahoo.fr.

involves multiple stages, each posing physical and chemical risks for dental laboratory technicians. metal, ceramic, porcelain, or synthetic resin, various hazards are present throughout the production process. One crucial step involves creating a positive mold using plaster.

In the manufacturing process for fixed metal and ceramic prostheses, wax models are cast to reproduce the tooth positively. The wax model is placed in a cylinder, filled with refractory material, and heated to remove the wax. The resulting empty mold is then filled with molten nickel-chromium alloy for metal prostheses. After cooling, the mold is broken, and the dentures undergo polishing using a sandblaster and hand finishing tools. For ceramic dentures, a ceramic layer is applied to the alloy with a brush before firing.

Resin prostheses may not always require a wax model. Instead, the negative impression is filled with methyl methacrylate resin, and the denture is finished by hand. In some cases, a cobalt-chrome alloy framework is necessary for metal partial dentures made of resin.

Airborne contaminants during the production process include plaster, refractory material (containing a high silica percentage), wax, nickel-chromium alloys, chromium, cobalt, ceramic, and resin. Although beryllium is used to enhance the hardness of nickel-chromium alloys, most current alloys are beryllium-free. The use of asbestos, which was previously employed as an insulating film between the cylinder and refractory material, has been prohibited since 1997.

Additionally, dental technicians work in an environment contaminated by mineral, organic, and metallic dust. They are exposed to various allergenic, skin-irritating, respiratory, and corrosive chemicals (Torbica and Krstev, 2006).

Therefore, the occupation of a dental technician is associated with an elevated risk of occupational pathologies, particularly pulmonary and dermatological issues, as indicated by Torbica and Krstev (2006). These health risks arise from a combination of factors: the use of materials with intrinsic dangers such as refractory materials and porcelain containing silica, metals (including toxic ones like beryllium, cobalt, chromium, nickel, and cadmium), as well as ceramics and methacrylic resins. Additionally, techniques employed in the profession, such as sanding and polishing, contribute to exposure during various phases of the work. Furthermore, the craft context of the profession introduces significant variability in professional practices.

Studies, such as Bernstein et al. (1994), have documented pulmonary retention of inhalable silica dust and certain metals, as evidenced by mineralogical analysis of bronchoalveolar lavage. This retention has been correlated with the length of exposure compared to a population not exposed to occupational hazards. Respiratory pathologies associated with dental technicians have been extensively researched internationally, indicating a high risk of pneumoconiosis, particularly silicosis, some cases of which can be severe (CDC, 2004). While exposure levels have decreased in certain countries, resulting in less symptomatic diseases primarily manifesting radiologically, the risk of pneumoconiosis remains higher in dental technicians compared to non-exposed individuals (Ergün et al., 2017). Notably, there is a heightened risk of berylliosis, a chronic condition resembling sarcoidosis, linked to sensitization to beryllium used in specific denture alloys, as observed in studies by Brancaleone et al. (1998) and Fireman et al. (2006). Additionally, allergic pathologies associated with methacrylic resins, including asthma and possible hypersensitivity pneumonitis, have also been reported in studies such as Marquardt et al. (2009), Radi et al. (2002) and Scherpereel et al. (2004).

It is worth noting that, in Senegal, no study has been conducted on the evaluation of respiratory disorders in dental technicians. The objective of this study is to assess the ventilatory function of Senegalese dental technicians.

MATERIALS AND METHODS

Study design

This descriptive and comparative cross-sectional study was conducted at the Physiology and Functional Explorations Laboratory of the Faculty of Medicine, Pharmacy, and Odontology at Cheikh Anta Diop University in Dakar, Senegal. The study involved different denture laboratories that were legally established in the Dakar region. The protocol was developed in accordance with the guidelines set out in the Declaration of Helsinki and received approval from the Ethics Committee of the Faculty of Medicine, Pharmacy, and Odontology at Cheikh Anta Diop University in Dakar. All participants willingly agreed to take part in the study by providing their informed consent through the signing of a voluntary and informed consent form.

Study population

Dental technicians were recruited from various dental laboratories and were compared with non-exposed workers (control group subjects). The study encompassed dental technicians who were legally practicing in the Dakar region and registered on the list of the National Association of Dental Technicians Prosthetists of Senegal. Participants were between 18 and 70 years old and had a minimum of one year of professional experience. They were employed in dental laboratories that held proper licensing.

The control subjects included in this study were healthy individuals with no exposure to the diverse products used in dental laboratories, such as metals, resins, and coatings. These control subjects were referred to the Physiology and Functional Explorations Laboratory for an employment visit. The control group population primarily consisted of office workers, salesmen, accountants, and secretaries. Control subjects were also aged between 18 and 70 years, and they were matched to dental technicians based on age, gender, weight, and height.

Excluded from the study were subjects in both groups who had a known or treated respiratory disease at the time of the study (such as asthma, COPD). Individuals with spinal or thoracic anomalies, neuromuscular diseases, chronic progressive cardiopulmonary pathology known at the time of the study, and pregnant women were also not included. Additionally, subjects with current or previous drug addictions and patients with diabetes were excluded from the study. All patients in whom we were unable to conduct the spirometry examination properly were excluded as well.

Sample and data collection

The sample size was determined using Schwartz's formula for descriptive studies. According to Schwartz's formula: $n= (\varepsilon\alpha)^2 pq/I^2$ where ε= reduced deviation= 1.96; α= risk of error= 0.05; p= theoretical prevalence = 50%. So, q= 1-p= 0.50; I= precision= 4%. Based on these parameters, on the list provided by the association of Senegalese dental technicians and on previous studies, we included a total of 80 patients, including 32 dental technicians and 48 controls free of any exposure. Data collection was carried out by two practitioners: an experimental dental physiologist (PAL) who collected anthropometric, medical and prosthetic data (weight, height, body mass index, medical self-questionnaire, self-questionnaire on occupational exposure and the nature of collective and individual protection used). Spirometric measurements and interpretation of the results were carried out by another medical physiologist experimenter (AKS) independently of the dental physiologist to avoid any methodological bias.

Anthropometric, medical and prosthetic parameters

Anthropometric data such as age, weight and height were determined. The weight of our subjects was measured with a SECA scale. The body mass index (BMI) of our subjects, expressed in kg/m², was calculated by the Quetelet formula: BMI= weight (kg)/height (m²). Weight was assessed in the morning at 8 am in barefoot and lightly dressed subjects.

All participants underwent a full clinical examination and completed a medical questionnaire on smoking habits, detailed medical history including medication use.

The medical questionnaire, focusing on respiratory health, covered allergy history, including nasal allergies, hay fever, and asthma. Reported asthma was defined by a positive response to the question "Have you ever had asthma?" Usual phlegm was defined as a positive response to the question "Do you usually have phlegm during the day or night?" Chronic bronchitis was characterized by cough and sputum for three or more months per year for at least two consecutive years. Dyspnea was defined as breathlessness when running on the flat or walking on a gentle slope.

Non-smokers were identified as individuals who had smoked fewer than one cigarette per day for one year, current smokers as those smoking more than one cigarette per day, and ex-smokers as those who had quit smoking at least one month before completing the questionnaire.

For both the exposed and unexposed groups, specific questions on immediate or delayed symptoms related to work tasks were incorporated into the medical questionnaire, encompassing cough, shortness of breath, and wheezing.

Volunteer dental technicians responded to a detailed self-questionnaire regarding their occupational exposure and the nature of collective and individual protection used. Prepared in collaboration with dental laboratory managers, the occupational questionnaire addressed the size and type of the laboratory (independent dental laboratory or dental practice), years of practice, collective protection equipment (such as an effective collection device, centralized suction unit, suction peg with collection device in the particle ejection path, suction hood above the ovens for heating fumes), personal protection equipment (masks, gloves, glasses), and tasks regularly performed to assess exposure (e.g., preparation of plaster, refractory material, or resin, wax modeling, melting of metal alloys like beryllium, cobalt, chromium, nickel, cadmium, breaking of the mold, sandblasting, manual finishing, polishing, and application of ceramics on metal alloys).

Spirographic recording

The spirometry was performed using a Jaeger PNEUMO care Fusion electronic spirometer coupled to a computer in which a data analysis software is installed. All the tests were performed at a specific time of day (10:00 am - 2:00 pm) to minimize daytime variations. The device was calibrated daily and operated in the ambient temperature range of 25 to 40 degrees Celsius. Explanations and supporting illustrations were provided in advance regarding the conduct of the examination. The tests were performed according to American Thoracic Society / European Respiratory Society guidelines (ATS / ERS guidelines) (Miller et al., 2005) in a quiet room seated with a soft nose clip. Subjects performed the spirometric tests three times at 15-min intervals and the best of the three was considered. The parameters recorded were: forced vital capacity (FVC) in litre, maximum expiratory volume in 1 second (FEV1) in litre, Tiffeneau ratio FEV1 / FVC expressed as a percentage, maximum expiratory flow at 25% of the FVC (FEF25%), maximum expiratory flow at 50% of the FVC (FEF50%), maximum expiratory flow at 75% of the FVC (FEF75%), maximum expiratory flow between 25 to 75% of the FVC (FEF25-75%). We defined the obstructive ventilatory disorder based on a decrease in the FEV1/FVC ratio (less than 70%) and an FEV1 < 80% of the predicted value with FEV1 < FEV1 and the restrictive ventilatory disorder based on a decrease in FEV1 < 80% of the predicted value and a normal FEV1/FVC ratio (>70%).

Statistical analysis

Data analysis will be conducted using R software version 3.2.3. The data will be presented as percentages, means, and standard deviations. A comparison of means will be performed using the Student's t-test. The Pearson test will be utilized to explore correlations between the various variables under investigation. The significance threshold has been set at $p < 0.05$, indicating statistical significance when the p-value is less than 0.05.

RESULTS

Description of the population

A total of 80 patients were included in the study, comprising 32 dental technicians and 48 control subjects free of any exposure. Three controls were excluded as they did not perform the spirometry maneuvers correctly. The final analysis included 32 dental technicians and 45 non-exposed workers (control subjects). The study population consisted of 70 men (90.62%) and 7 women (9.38%), with ages ranging from 21 to 60.

Within the groups, dental technicians comprised 29 men (91.43%) and 3 women (8.57%), while the non-exposed group included 41 men (91.11%) and 4 women (8.89%). Anthropometric data, such as age, height, weight, and body mass index (BMI), are presented in Table 1. The results indicated no statistically significant differences between the two groups in terms of age, sex, and BMI. The average age of dental technician subjects was 31.88±8.32 years, compared to 29.42±4.13 years for controls (p=0.13). The average BMI was 23.13±4.06

Table 1. Characteristics of dental technicians and control subjects.

Variable	Dental technicians (mean±SD)	Control subjects (mean±SD)	p-value
Age (years)	31.88±8.32	29.42±4.13	0.13
Weight (cm)	177.4±10.13	179.7±7.46	0.27
Height (kg)	72.40 ±10.54	70.52±10.86	0.36
BMI (kg/m^2)	23.13±4.06	22.03±2.98	0.42

BMI= Body Mass Index.

Table 2. Characteristics on protective measures and the prevalence of exposure among dental technicians.

Parameters	Dental technicians (n= 32) n(%)
Collective protection equipment	
Effective collection device	0
Centralized suction unit	0
Suction peg	3(9.38)
Suction hood	5(15.62)
No protection	24(75)
Personal protection equipment	
Masks	12(37.50)
Masks+gloves	2(6.25)
Masks+glasses	15(46.87)
Masks +gloves+glasses	3(9.38)
Exposure	
Asbestos	0(0)
Beryllium	1(3.13)
Silica	0(0)
Resin	32(100)
Plaster	32(100)
Wax	32(100)
Ceramic	18(56.25)
Nickel-chromium alloy	10(31.25)
Chrome-cobalt alloy	7(21.87)
Titanium	1(3.13)
No metal	13(40.62)
Duration of exposure (mean±SD)	7.67±2.78

kg/m2 in dental technicians and 22.03±2.98 kg/m2 for control subjects. Table 2 provides information on protective measures and the prevalence of exposure among dental technicians, with the mean duration of exposure in dental work calculated as 7.67±2.78 years.

Comparisons between dental technicians and non-exposed workers (control subjects)

Ventilatory symptoms

A total of 77 subjects filled in the medical questionnaire. Ventilatory symptoms were found only among dental technicians. Five dental technicians (15.62% of the exposed population) complained of symptoms related to their professional tasks (cough (n=3), shortness of breath (n=1) or wheezing (n=1)) during or after a working day.

None of these symptoms was significantly associated (p=0.8) with current occupational exposure (exposure to plaster, refractory materials, wax, metal alloys, resin or ceramics being expressed as present or absent). The prevalence of symptoms did not differ between dental technicians making metal prostheses and those making metal and resin prostheses.

Table 3. Average spirometric parameters in the dental technicians and control subjects.

Spirometric parameters	Dental technicians	Control subjects	p-value
FVC (L)	4.21±0.94	4.71±0.56	0.01*
FEV1 (L)	3.52±0.71	4.20±0.52	< 0.001*
FEV1/FVC (%)	84.03	89.09	0.01*
FEF 75% (L/s)	7.50±1.81	9.99±1.96	< 0.0001*
FEF 50% (L/s)	4,27±1.19	5,67±1.22	< 0.0001*
FEF 25-75% (L/s)	3.79±1.07	5,09±1.18	< 0.0001*
FEF 25% (L/s)	1,70±0.64	2,51±0.67	< 0.0001*

FVC= Forced Vital Capacity; FEV1= Forced Expiratory Volume in the first second; FEV1/FVC= ratio of FEV1 and FVC; FEF= Forced Expiratory Flow; *Significant difference (p<0.05).

Table 4. Comparison of spirometric parameters in the dental technicians with a duration of exposure < or > 10 years.

Spirometric parameters	Duration of exposure > 10 years	Duration of exposure < 10 years	p-value
FVC (L)	4.21±0.87	4.15±0.81	0.38
FEV1 (L)	3.49±0.61	3.54±0.52	0.27
FEV1/FVC (%)	81.53	83.36	0.79
FEF 75% (L/s)	7.46±1.61	7.59±1.76	0.25
FEF 50% (L/s)	3.77±1.19	4.17±1.24	0.12
FEF 25-75% (L/s)	3.48±1.07	3.88±1.16	0.18
FEF 25% (L/s)	1.40±0.64	1.74±0.69	0.28

FVC= Forced Vital Capacity; FEV1= Forced Expiratory Volume in the first second; FEV1/FVC= ratio of FEV1 and FVC; FEF= Forced Expiratory Flow.

Table 5. Distribution of ventilatory disorders in the dental technicians and control subjects.

Ventilatory disorders	Dental technicians n = 32 n(%)	Control subjects n = 45 n(%)	p-value
Proximal obstruction	0 (0)	0(0)	-
Distal obstruction	12 (37.50)	0(0)	< 0.001*
Central obstruction	5(15.62)	0(0)	0.05*
Restriction	5(15.62)	0(0)	0.02*
Collapse obstruction	1(3.12)	3(6.67)	0.8

*Significant difference (p<0.05).

Ventilatory function

When comparing dental technicians and control subjects, the averages of spirometric parameters, including forced vital capacity (FVC), forced first-second expiratory volume (FEV1), and maximum expiratory flow rates (FEF25%, FEF50%, FEF75%, and FEF25-75%), were significantly lower ($p < 0.05$) in dental technicians compared to control subjects (Table 3). Symptoms ($p > 0.2$) from those who were included in the analyses.

To assess the impact of exposure duration on spirometric parameters, dental technicians were divided into two subgroups: one with exposure duration <10 years (n=17) with an average duration of 3.12±1.81 years, and the other with exposure duration longer than 10 years (n=15) with an average of 12.22±3.75. There was no significant difference between the averages of the spirometric parameters between the groups (Table 4).

Ventilatory disorders

When comparing dental technicians and control subjects, ventilatory disorders, including distal and central obstructions, and restriction, were significantly higher ($p < 0.05$) in dental technicians compared to control subjects (Table 5). Distal obstruction (5 dental technicians) and restriction (2 dental technicians) were more prevalent in

Table 6. Association between current occupational exposure and ventilatory disorders in the dental technicians.

Ventilatory disorders exposure	Proximal obstruction	Distal obstruction	Central obstruction	Restriction	Collapse obstruction
Beryllium (n=1)	0	1	0	0	0
Resin (n=32)	0	12	5	5	1
Plaster (n=32)	0	12	5	5	1
Ceramic (n=18)	0	7	2	2	0
Nickel-chromium alloy (n=10)	0	5	1	2	0
Chrome-cobalt alloy (n=7)	0	2	2	1	
Titanium (n=1)	0	0	0	0	0
No metal (n=13)	0	4	3	2	0

P>0.05: no significant difference between current occupational exposure and ventilatory disorders.

only dental technician who used beryllium had a distal obstruction. However, there was no significant difference between metal users and non-users for each ventilatory disorder ($p > 0.05$) (Table 6).

DISCUSSION

This study was conducted on a population of volunteer dental technicians, involving a comprehensive medical assessment along with a detailed description of their working conditions and an evaluation of their ventilatory function. The strengths of this study lie in the comparison of the dental technician population with control subjects who had no exposure to various products used by dental technicians, including beryllium, cobalt, chromium, nickel, and methacrylic resins. The study was carried out on two anthropometrically comparable adult populations. Additionally, data collection was conducted blindly by two independent practitioners: an experimental dental physiologist (PAL) for anthropometric, medical, and prosthetic data, and an experimental medical physiologist (AKS) for spirometric measurements and result interpretation, aiming to prevent any methodological bias that could influence the outcomes.

However, certain limitations must be acknowledged. The sample size (a total of 32 dental technicians and 45 controls) may limit the study's statistical power. Additionally, it cannot be ruled out that the volunteer dental technicians may represent a sample more conscious of the risks associated with their profession and its prevention. The mean body mass index (BMI) was 23.13±4.06 kg/m^2, ranging from 17.63 to 34.85 kg/m^2. A study by Moins et al. (2016) reported a mean BMI of 25.4±3.6, which is close to our findings. The prevalence of smoking among dental technicians in other studies was significantly higher than in our study, possibly due to variations in behavioral habits between Western countries and certain African countries, including Senegal. In our study, only one dental technician was a smoker, in contrast to a study in Turkey where 69% of dental technicians had a history of smoking. The stressful working conditions in Western countries might explain the higher percentage of smoking dental technicians observed in those studies (Doğan et al., 2010).

The investigation into symptoms associated with ventilatory disorders revealed that five dental technicians (15.62% of the exposed population) reported symptoms related to their professional tasks—specifically, cough (n=3), shortness of breath (n=1), or wheezing (n=1)—during or after a working day. None of these symptoms were significantly associated (p=0.8) with current occupational exposure, where exposure to plaster, refractory materials, wax, metal alloys, resin, or ceramics was expressed as present or absent. None of these symptoms were observed in the one dental technician who was a smoker. Moreover, these symptoms were not reported among our control subjects. In contrast to our findings, a study by Doğan et al. (2010) demonstrated that nearly half of the dental technicians suffered from dyspnea and mucus expectoration.

It is noteworthy that many dental technicians in our study used protective equipment, such as masks, gloves, and glasses. Previous research has shown that dental technicians work in an environment contaminated by mineral, organic, and metallic dust, along with exposure to numerous allergenic, skin-irritating, respiratory, and corrosive chemicals. Consequently, the dental technician profession is associated with an increased risk of occupational pathologies (Torbica and Krstev, 2006).

A study conducted in 2016, using a similar approach, revealed that, in terms of current functional signs, respiratory symptoms were reported by 45% of dental technicians seen in consultation, with manifestations including isolated dyspnea (NYHA class I to II for 6 of them, NYHA III for 2 dental technicians) or chronic cough (n=3). One dental technician exhibited an irritative cough during the "lost wax" stage and methacrylate-based resin use, leading to bronchial hyperreactivity. Skin symptoms were also reported, with a quarter of the dental technicians experiencing skin symptoms, primarily mechanical in origin, localized to the upper limbs, and pruritus on the hands (Moins et al., 2016). It's important to note that this study was conducted in France under more favorable working conditions. A similar study on the same number of subjects (32) revealed that mucus expectoration was the most common symptom, and dyspnea prevalence was higher in dental technicians, especially those with a high International Labour Office (ILO) profusion score ($p < 0.01$) (Berk et al., 2016).

In our study, the spirometric examination revealed that all spirometric parameters were higher in the control group than in the dental technician group, with a significant difference observed throughout between the two groups. In previous studies (Choudat et al., 1993; Froudarakis et al., 1999; Sherson et al., 1988), spirometric parameters were slightly decreased in the dental prosthesis group, although no significant statistical difference was found between the two groups. Subsequently, the study by Moins et al. (2016) showed an excessive presence of respiratory symptoms in dental technicians, with lower spirometric parameters compared to non-exposed subjects. The mean values of FVC (%), FEF 25 and FEF 50% were significantly decreased in dental technicians (Moins et al., 2016). Radiographic abnormalities were associated with a higher prevalence of respiratory symptoms and reduced spirometric parameters (Radi et al., 2002). These results align with those of our study.

However, in a study conducted by Doğan et al. (2010) the values of pulmonary function parameters in the dental technician group were not significantly different from those of the control group except for FEV1.

Regarding ventilatory disorders, no proximal obstructions were found in our results. Distal and central obstructions, as well as restriction, were higher in the dental technician group than in the controls, with significant differences observed between the two groups. However, collapse obstructions were higher in controls than in dental technicians, with no significant difference between the two groups.

According to the study by Moins et al. (2016) cumulative activity is associated with a tendency to bronchial obstruction, as the Tiffeneau ratio FEV1/FVC, maximum expiratory flow at 25% of the FVC (FEF25%), maximum expiratory flow at 50% of the FVC (FEF50%), maximum expiratory flow at 75% of the FVC (FEF75%), and maximum expiratory flow between 25 to 75% of the FVC (FEF25-75%) are negatively related to the number of prostheses per year after controlling for age and smoking status: $r = -0.56$ ($p = 0.023$) and $r = -0.63$ ($p = 0.004$), respectively.

In our study, no correlation was found between spirometric parameters and age, duration of exposure, and smoking status.

To assess the impact of exposure duration on spirometric parameters, dental technicians were categorized into two subgroups: one with exposure duration <10 years (n=17) with an average duration of 3.12±1.81 years, and the other with exposure duration longer than 10 years (n=15) with an average of12.22±3.75. There was no significant difference between the averages of the spirometric parameters between the two groups. In our study, we were unable to measure the duration of exposure in hours among Senegalese dental technicians due to the lack of available data. The workload in a dental laboratory varies from one technician to another on a daily basis. Therefore, exposure should have been measured in hours rather than over a period. This limitation in our study possibly explains the absence of a statistically significant relationship between exposure duration and spirometric parameters.

Generally, an obstructive ventilatory abnormality can be observed in simple spirometric tests on individuals exposed to dust. This pattern is more associated with smoking than with industrial bronchitis and emphysema. In the presence of obstructive emphysema, air distribution to the lungs breaks down. Progressive massive fibrosis and a restrictive ventilatory defect occur in pneumoconiosis. Forced vital capacity (FVC) is decreased due to the reduced capacity of the lungs and the limitation of expansion. The subdivisions of forced vital capacity (inspiratory reserve volume, tidal volume, and expiratory reserve volume), inspiratory capacity, and lung volume may also be reduced. These variations are particularly prevalent in people who smoke. Since a decrease in FEV1 parallels a decrease in FVC, the percentage of FEV1/FVC is normal (Doğan et al., 1993; Hedenström and Malmberg, 1983). These results align with our own findings.

All the dental technicians worked in an environment without ventilation systems. However, there was no significant difference between current occupational exposure and ventilatory disorders ($p>0.05$). It has been demonstrated that obstructive ventilatory impairment can be observed in simple spirometric tests on individuals exposed to dust (Hedenström and Malmberg, 1983). Distal obstruction (observed in 5 dental technicians) and restriction (observed in 2 dental technicians) were higher in users of the chromium + cobalt metal combination. The only denturist who used beryllium had a distal obstruction. However, there was no significant difference between metal users and non-users for each ventilatory disorder ($p > 0.05$). Ventilatory disorders (distal and central obstructions and restriction) were significantly higher ($p<0.05$) in dental technicians compared to control subjects.

In most small laboratories, there is no proper exhaust and ventilation system in the workplace, exposing dental technicians to numerous airborne contaminants during processes such as the preparation of refractory material, mould breaking, sanding, and polishing. Hand finishing also exposes them to metal alloys (beryllium) and resin. Additionally, pneumoconiosis is often discovered incidentally during a chest X-ray (Berk et al., 2016; Ergün et al., 2017; Kahraman et al., 2014). Although most current chromium-cobalt alloys are beryllium-free, their exact composition is not always known. Signs of early morbidity increase with the duration of work in the dental profession, raising concerns. Most dental technicians start working at the age of 18 and often do not change their jobs. Moreover, this population is still at risk of pneumoconiosis (Berk et al., 2016; Ergün et al., 2017; Kahraman et al., 2014).

This study underscores the necessity for technical preventive measures, control of occupational exposure, and the replacement of hazardous materials if possible (such as silica, heavy metals, beryllium) (Radi et al., 2002). Dental laboratories must undergo an in-depth risk analysis to enable the drafting of the Single Safety Document, assessing both the material and technical environment (tools, machines, products used) and the effectiveness of existing means of protection and their use according to the workstations. The most effective prevention is primary prevention, involving the implementation of technologies that allow actions on products and/or processes, such as the use of materials or machines that eliminate or limit impacts as much as possible, with very low atmospheric emissions and low noise levels. Collective prevention involves the use of sealed enclosures and mechanical devices, such as dust and vapor extraction, to reduce worker exposure, particularly when hazardous chemicals cannot be replaced by others for technical reasons. Finally, the wearing of personal protective equipment (coveralls, gloves, protective shoes and glasses, masks, etc.) is mandatory to reduce the risk of exposure not totally eliminated by collective protective measures, along with the presence of first aid facilities and equipment.

Conclusion

The authors result showed that all the spirometric parameters measured were higher in the control group with a significant difference than in the dental technician group. Ventilatory disorders were significantly higher ($p<0.05$) in dental technicians than in control subjects. These results indicate an impairment of ventilatory function in dental technicians compared to controls. Further studies combining the evaluation of spirometric parameters, chest X-rays and the determination of urinary concentrations of metals used in the manufacture of prosthetic parts are required.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENT

The authors would like to thank the Department of Prosthodontics, IOS, UCAD, Senegal, and the National Association of Dental Technicians Prosthetists of Senegal for their kind cooperation.

REFERENCES

Bernstein M, Pairon JC, Morabia A, Gaudichet A, Janson X, Brochard P (1994). Non-fibrous dust load and smoking in dental technicians. A study using bronchoalveolar lavage. Occupational Environmental Medicine 51(1):23-27.

Berk S, Dogan DO, Gumus C, Akkurt I (2016). Relationship between radiological (X-ray/HRCT), spirometric and clinical findings in dental technicians' pneumoconiosis. The Clinical Respiratory Journal 10(1):67-73. https://doi.org/10.1111/crj.12187. PMID: 25043510.

Brancaleone P, Weynand B, De Vuyst P, Stanescu D, Pieters T (1998). Lung granulomatosis in a dental technician. American Journal of Industrial Medicine 34(6):628-631. https://doi.org/10.1002/(sici)1097-0274(199812)34:6%3C628::aid-ajim12%3E3.0.co;2-9. PMID: 9816422.

Centers for Disease Control and Prevention (CDC) (2004). Silicosis in dental laboratory technicians--five states, 1994-2000. MMWR Morbidity and Mortality Weekly Report 53(9):195-197. PMID: 15017375.

Choudat D, Triem S, Weill B, Vicrey C, Ameille J, Brochard P, Letourneux M, Rossignol C (1993). Respiratory symptoms, lung function, and pneumoconiosis among self employed dental technicians. British Journal of Industrial Medicine 50(5):443-449. https://doi.org/10.1136/oem.50.5.443. PMID: 8507597.

Doğan A, Doğan OM, Karabiyikoğlu G, Aydin C (1993). Pulmonary function parameters, arterial blood gases and flow volume curves of dental technicians. The Journal of Nihon University School of Dentistry 35(1):16-21. https://doi.org/10.2334/josnusd1959.35.16. PMID: 8326369.

Doğan DÖ, Ozdemir AK, Polat NT, Dal U, Gümüş C, Akkurt I (2010). Prevalence of respiratory abnormalities and pneumoconiosis in dental laboratory technicians. Tuberkuloz ve Toraks 58(2):135-141. PMID:20865565.

Ergün R, Ergün D, Evcik E, Ergan B (2017). Evaluation of dental technician's pneumoconiosis using chest X-rayand HRCT: correlation between radiological and functional findings. Turkish Journal of Medical Sciences 47(1):252-259. https://doi.org/10.3906/sag-1604-146. PMID: 28263498.

Fireman E, Kramer MR, Priel I, Lerman Y (2006). Chronic beryllium disease among dental technicians in Israel. Sarcoidosis Vasculitis and Diffuse Lung Diseases 23(3):215-221. PMID: 18038921.

Froudarakis ME, Voloudaki A, Bouros D, Drakonakis G, Hatzakis K, Siafakas NM (1999). Pneumoconiosis among Cretan dental technicians. Respiration 66(4):338-42. https://doi.org/10.1159/000029404. PMID: 10461082.

Hedenström H, Malmberg P (1987). Optimal combinations of lung function tests in the detection of various types of early lung disease. European Journal of Respiratory Diseases 71(4):273-85. PMID: 3691683.

Kahraman H, Koksal N, Cinkara M, Ozkan F, Sucakli MH, Ekerbicer H (2014). Pneumoconiosis in dental technicians: HRCT and pulmonary function findings. Occupational Medicine (London) 64(6):442-447. https://doi.org/10.1093/occmed/kqu047. PMID: 24739899.

Marquardt W, Seiss M, Hickel R, Reichl FX (2009). Volatile methacrylates in dental practices. The Journal of Adhesive Dentistry 11(2):101-107. PMID: 19492711.

Miller MR, Hankinson J, Brusasco V, Burgos F, Casaburi R, Coates A, Crapo R, Enright P, van der Grinten CP, Gustafsson P, Jensen R, Johnson DC, MacIntyre N, McKay R, Navajas D, Pedersen OF, Pellegrino R, Viegi G, Wanger J, ATS/ERS Task Force (2005). Standardisation of spirometry. The European Respiratory Journal 26(2):319-338. https://doi.org/10.1183/09031936.05.00034805. PMID: 16055882.

Moins L, Persoons R, Barbeau D, Balducci F, Maitre A, Bonneterre V (2016). Evaluation de l'état de santé, des risques professionnels et de l'exposition aux métaux d'une population de prothésistes dentaires. Archives des Maladies Professionnelles et de l´Environnement 77(6):971-972.

https://doi.org/10.1016/j.admp.2016.05.005.

Radi S, Dalphin JC, Manzoni P, Pernet D, Leboube MP, Viel JF (2002). Respiratory morbidity in a population of French dental technicians. Occupational and Environnemental Medicine 59(6):398-404. https://doi.org/10.1136/oem.59.6.398. PMID: 12040116.

Scherpereel A, Tillie-Leblond I, Pommier de Santi P, Tonnel A (2004). Exposure to methyl methacrylate and hypersensitivity pneumonitis in dental technicians. Allergy 59(8):890-892. https://doi.org/10.1111/j.1398-9995.2004.00511.x. PMID: 15230827.

Sherson D, Maltbaek N, Olsen O (1988). Small opacities among dental laboratory technicians in Copenhagen. British Journal of Industrial Medicine 45(5):320-324. https://doi.org/10.1136/oem.45.5.320. PMID: 3378011.

Soulat J, Marpinard M, Esquirol Y, Delalain P, Lafon D, Pujol M (2000). Exposition à la silice chez les prothésistes dentaires. Archives des Maladies Professionnelles et de l´environnement 61(3):156-161.

Torbica N, Krstev S (2006). World at work: Dental laboratory technicians. Occupational and Environmental Medicine 63(2):145-148. https://doi.org/10.1136%2Foem.2004.019059. PMID: 16421395.